Characterization and Melodic Similarity of A Cappella Flamenco *Cantes*

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ABSTRACT

This paper intends to research on the link between musical similarity and style and sub-style (variant) classification in the context of flamenco a cappella singing styles. Given the limitation of standard computational models for melodic characterization and similarity computation in this particular context, we have proposed a specific set of melodic features adapted to flamenco singing styles. In order to evaluate them, we have gathered a collection of music recordings from the most representative singers and have manually extracted those proposed features. Based on those features, we have defined a similarity measure between two performances and have validated their usefulness in differentiating several styles and variants. The main conclusion of this work is the need to incorporate specific musical features to the design of similarity measures for flamenco music so that flamenco-adapted MIR systems can be developed.

1. INTRODUCTION

There is a wealth of literature on music research that focuses on the understanding of music similarity from different viewpoints as well as the use of similarity distances to cluster different pieces according to artist, genre or mood. Over the past few years, the Music Information Retrieval (MIR) community has been exploring several ways to measure the similarity between two musical pieces. They are often based on comparing musical excerpts in audio format and computing the distance between a representative set of their musical features (e.g., instrumentation, rhythmic patterns or harmonic progressions). This way, current systems can, for instance, locate different versions of the same song with a high accuracy rate [9].

Alternative approaches are based on comparing contextual information from the considered pieces or artists (e.g., influences, temporal coincidences, geographical location), which is usually extracted from the web. A combination of these two approaches seems to be the most adequate solution [2], but there is still a glass ceiling on current systems. This seems to be owing to the fact that there are still fundamental musical features to be considered or fully incorporated into existing models [10].

On the other hand, research on music similarity has mainly focused on the analysis of music from the so-called "Western tradition", although there is an increasing interest in analyzing music from different traditions, and some recent MIR studies are devoted to this issue [3].

In this paper we study the relationship between music similarity and style definition in the context of a group of flamenco a cappella singing styles. Because of its oral transmission, formal classification and musical analysis of flamenco present considerable difficulties. Classification of styles is usually carried out by flamenco experts and rests upon the analysis of the oral corpus of flamenco music. Flamenco experts have used several criteria in their classification, some of which, unfortunately, are not fully explicit and clear-cut. Moreover, there exists considerable controversy among flamenco experts and at present there is a lack of a unified, unequivocal classification of a cappella *cantes*.

Our previous research has focused on analyzing the relationship between music similarity and style definition from different perspectives, such as computational models for melodic similarity [3] and human ratings of rhythmic patterns [6]. In Cabrera et al. [3], we applied standard melodic similarity measures to a music collection of a cappella flamenco music. Extraction of melodic contours, although arduous, produced faithful descriptions of *cantes*. However, when applied some standard algorithms for comparing melodic contours (i.e. correlation between pitch and interval histograms and edit distance), we obtained rather poor results. Although global style classification seemed to work to some extent, flamenco experts found that for variant classification of some styles those algorithms failed to distinguish subtle, specific nuances of the *cantes*. We applied some clustering techniques and it turned out that c*antes* that by musical reasons should be scattered were unexpectedly clustered together. Thus, we concluded that further research had to be carried out. It soon became apparent that two tasks, at least, had to be accomplished: first, to musically formalize the specific and subtle features of a cappella *cantes*; second, to refine our computational models according to those features.

This paper intends to research on the link between musical similarity and style classification and sub-style

(variant) definition in the context of flamenco a cappella singing styles. The main contributions are (1) Identify relevant and specific features that characterize a given performance in the context of its style. Here, we consider that each style is characterized by a prototypical melodic contour. The features will then account for variations within this contour. (2) Define a similarity measure based on the identified features and provide an automatic method of clustering and classification. (3) Evaluate the results with a music collection of recordings from the most representative performers and contrast them with existing theories for the definition of styles and variants.

This paper is organized as follows. In the next two sections we analyze the characteristics of flamenco singing and a cappella *cantes*. Next we give an overview of the *cantes* to be analyzed and we describe the music collection used in our study. We then present the set of features that describes the two chosen *cantes*, namely, *deblas* and *martinetes*. The following section deals with the similarity distance between *cantes*. A conclusion section summarizes the main findings and presents some proposals for future research.

2. FLAMENCO SINGING

We now describe the main features that characterize flamenco singing and differentiate it from other styles:

- **Instability of pitch**. In general, notes are not clearly attacked. Pitch glides or *portamenti* are very common.
- **Sudden changes in volume** (loudness).
- **Short pitch range *or tessitura.*** It is normally limited to a major sixth interval and characterized by the insistence on a note and those contiguous.
- **Intelligibility of voices.** Since lyrics are important in flamenco, there is a strong preference for intelligibility over range or timbre. Contralto and baritone voices are very common.
- **Timbre**. Timbre characteristics of flamenco singers depend on the period in which it was performed. As relevant timbre aspects, we can mention breathiness in the voice and the absence of high frequency (singer) formant, which is characteristic of classical singing styles.

From a musical point of view, a cappella *cantes* retain the following properties.

- **Conjunct degrees.** Melodic movement mostly occurs by conjunct degrees.
- **Scales.** Certain scales such as the dominant Phrygian mode (with a major tonic) and Ionian mode (E-F-G#-A-B-C-D) are predominant.
- **Ornamentation**. There is also a high degree of complex ornamentation, melismas being one of the most significant devices of expressivity.
- **Microtonality.** The use of intervals smaller than the equal-tempered semitones of Western classical music is frequent.
- **Enharmonic scales.** Microtonal interval differences between enharmonic notes.

Classification of a cappella *cantes* is subject to many difficulties. Two *cantes* belonging to the same style may sound very different to an unaccustomed ear. In general, underlying each *cante* there is a melodic skeleton. Donnier [4] called it the "*cante's* melodic gene". The singer fills this melodic skeleton by using different kind of melismas, ornamentation and other expressive resources. A flamenco aficionado recognizes two versions as to be the same *cante* because certain notes appear in certain order. What happens between two of those notes does not matter regarding style classification, but does matter for assessing a performance or the piece itself. Aficionado's ears recognize the wheat from the chaff when listening and appreciate a particular performance in terms of the quality of the melodic filling, among other features.

In order to put the reader in the position of understanding this point, in Figures 1 and 2 we show a transcription of two versions of the same *cante* to Western musical notation. In this respect, Western notation has been found limited for this kind of music (e.g. Donnier [4] proposed the use of plainchant neumes).

Figure 1: Manual transcription of a *cante* (debla).

Figure 2: Transcription of another version of the previous *cante*.

3. THE STYLES OF TONÁS

As defined earlier, a cappella *cantes* are songs without instrumentation, or in some cases with some percussion *(*in the flamenco argon also *cantes a palo seco)*. An important group of such *cantes* is composed of *tonás*, style that generically include *martinetes, deblas, saetas, tonás* and *carceleras*. Since in flamenco music the word *toná* refers to both the style and one of its variants, we will refer to "*tonás* style" as the whole style and *toná* as the substyle or *cante*.

These *cantes* are played in free rhythm (sometimes the pattern of *seguiriya* is used as rhythmic accompaniment). Each singer chooses his or her own reference pitch. Modality, depending on the particular style, may be either the major mode or the Andalusian mode (Phrygian mode with a tonic major chord), though frequently both modes alternate within the same song [5]. Lyrics of these songs range widely. Lefranc [8] carried out a classification of the *tonás* style mainly based on lyrics. Blas Vega [1] also studied the *tonás* style from a historical standpoint. A *toná* typically possesses verses formed by words either of three or four syllables, or eight syllables, where the second and the forth verses may have assonant rhyme; often the final verse finishes with an imperfect tercet (a tercet is a group of three lines of a verse; an imperfect tercet is an off-rhyme tercet).

The *toná cante* is normally sung in a four-verse form of eight syllables each. Rhyme is assonant on even verses. The *toná cante* appears in several modes, the Phrygian mode being the most prevailing one. Ionian or Aeolian modes can also be found as well as alternation of two modes. Ornamentation is very complex and profuse; no strict tempo is followed at all.

4. MUSIC COLLECTION

To start with, we gathered a set of 365 pieces belonging to the *tonás* style. Somehow, these *cantes* have scarcely been recorded compared to other styles. Their ritual mood and lyricism might be a plausible reason for that shortage of recordings. In spite of that, we spared no effort to gather as many recordings as possible from all feasible sources (private collections, libraries, historical recordings, several institutions, etc.). We may safely state that our collection is quite representative of this type of *cantes*.

After the analysis phase of the corpus, we decided to focus on two styles, *deblas* and *martinetes*, because: (1) Both styles are central to flamenco music; (2) Contrary to other *cantes*, we had information about singers, geographical locations, singing schools, dates, etc., which allows us to have a complete, in-depth characterization of them from a more general standpoint than just the musical one; (3) In general, recordings had acceptable quality to carry out this research and the future ones, which include, for instance, automatic feature extraction from audio files; (4) There was a high number of recordings, 72 songs in total, where 16 were *deblas* and 56 *martinetes*; (5) Apart from the number, there was enough variability in the sample for a proper evaluation of our methods.

The specific feature set of *deblas* and *martinetes[1]*, to be described below, were obtained after a thorough study. First, we opened an analysis phase to identify which musical features were relevant to the characterization of the chosen *cantes*. Preliminary analysis produced too many variables or just variables with little explanatory power. Next, in search of the least complex yet meaningful de-

scription of *cantes*, we removed several variables. Most of the features identified were related to melody and form. During the analysis, in our mind it also underlay the idea of capturing some of the features used by flamenco experts and aficionados to recognize the different styles. After deciding on the final feature set, we manually extracted it for the different performances. A working group of flamenco experts agreed on the proposed feature set and annotations. The next two sections describe the musical features in detail.

5. MUSICAL FEATURES

5.1. Deblas

The *debla* is a song from the style of *tonás*. In general, it is marked by its great melismatic ornamentation, more abrupt than the other songs from this style, which characterizes its melody. Deblas are characterized by a particular melodic contour.

The musical features that characterize the different variants within the *debla* style can be summarized as follows:

1. **Beginning by the word ¡Ay!**: ¡Ay! is an interjection expressing pain, which is quite idiosyncratic to flamenco music. Values of the variable: Yes and no.
2. **Linking of ¡Ay! to the text.** That initial ¡Ay! may be linked to the text or just be separated from it. Values of the variable: Yes and no.
3. **Initial note.** It refers to the first note of the tercet. Normally, it is the sixth degree of the scale (VI), but the fifth degree (V) can also appear. Values of the variable are 5 and 6.
4. **Direction of melody movement in the first hemistich** (a hemistich is half of a line of a verse.) The direction can be descending (fast appoggiatura in V, then the progression VI-IV), symmetric (III-VI-IV) or ascending. Values here are *D*, *S* and *A*.
5. **Repetition of the first hemistich.** That repetition may be of the whole hemistich or just a part of it. Values of the variable: Yes or no.
6. **Caesura.** The caesura is a pause that breaks up a verse into two hemistiches. Values of the variable: Yes and no.
7. **Direction of melody movement in the second hemistich,** defined as in the first hemistich. Values of the variables are *D*, *S* and *A*.
8. **Highest degree in the second hemistich.** It is the highest degree of the scale reached in the second hemistich. Usually, the seventh degree is reached, but fifth and sixth degrees may also appear. Values of the variable are 5, 6 and 7.
9. **Frequency of the highest degree in the second hemistich.** The commonest melodic line to reach the highest degree of the scale consists of the concatenation of two *torculus*. A *torculus* is a neume signifying three notes, the second higher than the others. The value of this variable indicates how many times this neume is repeated in the second hemistich.

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10. **Duration.** Although the duration is measured in ms, our intention was to classify the *cantes* into three categories, fast, regular and slow. To do so, we first computed the average μ and the standard deviation σ of the durations of all the *cantes* in the same style. Then, fast *cantes* are those whose duration is less than μ-σ, regular *cantes* have their duration in the interval [μ-σ, μ+σ], and slow *cantes* have durations greater than μ+σ. Values of this variable are *F, R* and *S*.

5.2. Martinetes

The *martinete* is also considered a variant of the *toná*. It differs from *deblas* in the theme of its lyrics and in its melodic model, which always finishes in the major mode. *Debla*'s mood is usually sad, played without guitar accompaniment, like the other *tonás*. *Martinetes*, however, are usually accompanied by the sound of a hammer struck against an anvil.

There are three clear variants of *martinetes*. The first one, to be called *martinete* 1, has no introduction, whereas the second one, to be called *martinete* 2, starts with a couple of verses from a *toná*. The third one, to be called *martinete* 3, is a concatenation of a *toná* and some of the previous variants of *martinetes*; the *toná* of *martinete* 2 and 3 is called *toná* incipit. A trait of *martinete* 3 is the singing of several poems, all having the same theme as in medieval romances. Because *martinete 3* is a combination of *toná* and *martinetes 1* and *2,* we removed it from our current study, as we just sought characterizing the most fundamental styles.

Next, musical features of *martinete 1* are presented.

1. **Repetition of the first hemistich.** As for *deblas,* repetition may be complete or partial. Values of the variable: Yes and no.
2. **Clivis/flexa** (a neume of two notes, the second lower than the first one) **at the end of the first hemistich.** Normally, fall IV-III or IV-IIIb are found. The commonest ending for a tercet is the fourth degree, whose sound is sustained until reaching the caesura. Some singers like to end on III or IIIb. Values of the variable are: Yes and no.
3. **Highest degree in both hemistiches.** The customary practice is to reach the fourth degree; some singers reach the fifth degree. Values of the variable are 4 and 5.
4. **Frequency of the highest degree in the second hemistich.** The melodic line is formed by a *torculus,* a three-note neume, III-IV-III in this case. This variable stores the number of repetitions of this neume.
5. **Final note of the second hemistich.** The second hemistich of *martinete 1* is ended by falling on the second degree. Sometimes, the second degree is flattened, which produces Phrygian echoes in the cadence. This variable takes two values, *1* when the final note is the tonic and *2* when the final note is II.
6. **Duration.** This variable is defined as in the case of *deblas* (that is, in terms of μ and σ). Values of this variable are *F, R* and *S*.

As for *martinete 2* we have the following features.

1. **Highest degree in both hemistiches.** In this case the customary practice is to reach the sixth degree; in some cases singers just reach the fourth or fifth degrees. Values of the variable are 4, 5 and 6.
2. **Frequency of the highest degree in the second hemistich.** In this case the neume is also a *torculus*. This variable stores the number of repetitions of this neume.
3. **Symmetry of the highest degree in the second hemistich.** The second hemistich of a *martinete 2* is rich in melismas. This feature describes the distribution of the melismas around the highest reached degree, which is usually the sixth degree. Melismas can occur before and after reaching the highest degree (symmetric distribution), only before the highest degree (left asymmetry) or only after the highest degree (right asymmetry).
4. **Duration.** This variable is defined as in the previous cases. Values of this variable are *F, R* and *S*.

6. SIMILARITY COMPUTATION

6.1 Inter-Style Similarity

Carrying out the preceding analysis allowed us to extract a set of musical features to be used in the definition of melodic similarity between *cantes*. As a matter of fact, just using features very peculiar to a given style would distort the analysis, as their discriminating power would be very high. Our intention was to select a set of a few features capable of discriminating between different cantes. We removed those variables that only made sense within one style, gathering the following final set:

1. **Mode of type of scale**: Ionian (major mode), dominant Phrygian (Phrygian mode with a major third) or bimodal (alternation of both modes). This variable makes sense to classify the different styles.
2. **Direction of melody movement in the first hemistich**.
3. **Symmetry of the highest degree in the second hemistich.**
4. **Clivis (or flexa) at the end of the first hemistich.**
5. **Repetition of the first hemistich.**
6. **Initial note.**
7. **Final note of the second hemistich.**
8. **Highest degree in both hemistiches.**
9. **Frequency of the highest degree in the second hemistich with respect to a cante.** This variable has been normalized as follows. Let μ be the average of the frequencies of the all *cantes*, and σ its standard deviation. The frequency takes three values, 0 (seldom), if the frequency is less than μ-σ; 1 (normal) if it is within the interval [μ-σ, μ+σ]; and 2 (often), when it is greater than μ+σ.
10. **Frequency of the highest degree in the second hemistich with respect to the whole corpus.** In this

case the mean and the standard deviation are taken with respect to all pieces in the corpus.

11. **Duration with respect to the piece.** This variable is defined as above, taking three values fast, regular and slow.

12. **Duration with respect to the whole corpus**. Now the mean and the standard deviation are computed for the whole corpus.

Note that some of these variables do not appear as specific features in some cante. We removed those variables that only accounted for one cante and tried to keep the smallest set of explanatory variables. Moreover, we performed a principal component analysis (SPSS 15 were used for this). As a consequence, two variables were discarded: *Clivis* (or *flexa*) at the end of the first hemistich and repetition of the first hemistich. The number of final dimensions turned out to be 3 and the Cronbach's alpha equalled 0.983, a very good value, indeed.

The distance we used to measure the similarity between two cantes was the simplest one could think of: the Euclidean distance between features vectors. Our intention was to test how powerful the musical features would be. The Euclidean is just a geometrical distance and does not reflect perceptual distance whatsoever. However, because of the robustness and power of the musical features, results were good.

We used phylogenetic trees [7] to better visualize the distance matrix. For the actual computing, we used the tool SplitsTree [7]. SplitsTree computes a tree (or more generally a graph) with the property that the distance in the drawing between any two nodes reflects as closely as possible the true distance between the corresponding two pieces in the distance matrix. In general, clustering and other properties are easier to visualize with phylogenetic trees.

6.2 Intra-Style Similarity

On a second step, we analyzed similarities between performances within each particular style. In this case, we considered all the variables presented below for each particular style (*martinete1*, *martinete2* or *debla*). We computed the corresponding distance matrices and generated their phylogenetic trees. As before, we used the Euclidean distance. Again, our intention was to evaluate how well the defined features characterize these *cantes*.

7. RESULTS

7.1 Inter-Style Similarity

Regarding style classification, Figure 2 displays the phylogenetic tree obtained for the whole corpus under study. Label Dx stands for *debla*, label M1 stands for *martinete 1* and label M2 for *martinete 2*.

As it can be noticed, discrimination among *cantes* is very good. There are three clearly separated clusters, each corresponding to a *cante.*

In addition, we have computed for each *cante* its closest neighbour and checked if both belong to the same style. That was the situation for 88.6% of the cases. There was a striking case in one particular *debla. Debla D2-14* whose three nearest neighbours turned out to be of class *martinete 2.* That *debla* is one of the oldest known songs, according to our musicological knowledge. Meaningfully enough, the closest *martinetes* are also old, which suggests a possible common origin or an evolution of *martinete 2* from *debla* (*martinete 2* seems to be a mixture of previous *cantes*). Those *martinetes* are *M2-66, M2-68* and *M2-65*; see Figure 3 at the end of this paper.

We also observed that some distance values were equal to zero for the same style; this will be discussed later in the conclusions section. Finally, precision and recall, two common performance measures, curves are provided in Figure 4.

7.2 Intra-Style Similarity

We did not expect a very fine clustering in the intra-style case, as the musical features account for general properties rather than for specific properties. In general, there was one big cluster, often with several *cantes* having the same distances. Overall, this was in general coherent to the expert's knowledge on the musical relation among performers.
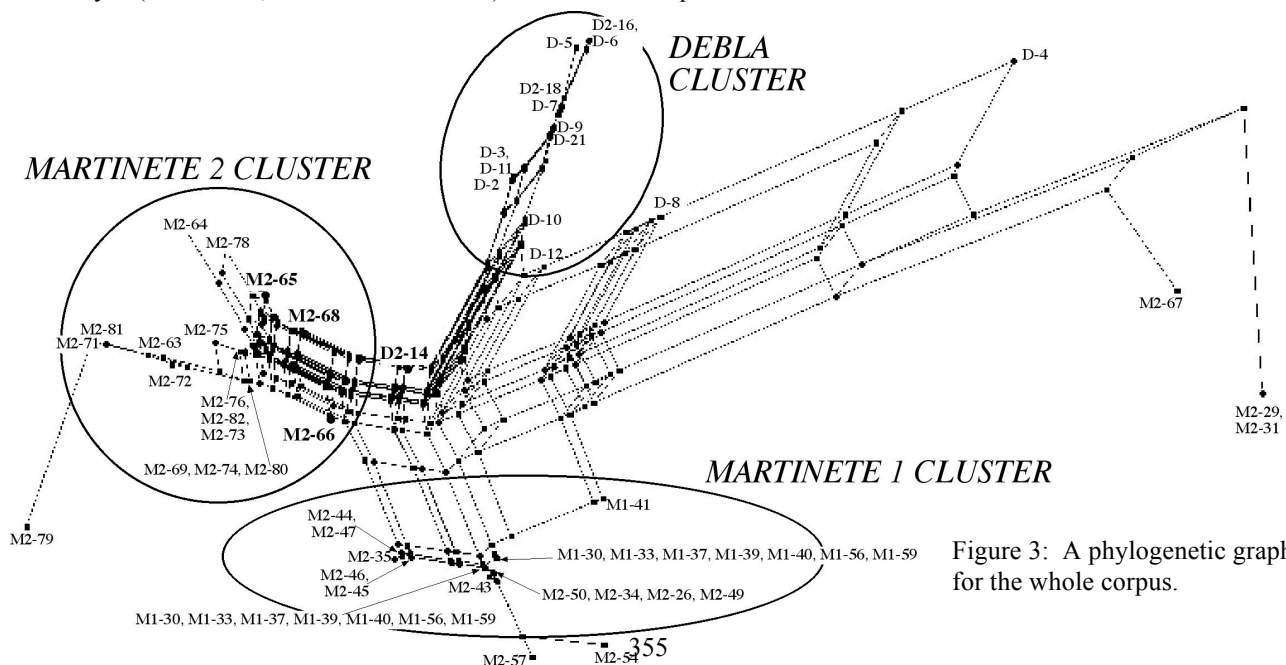

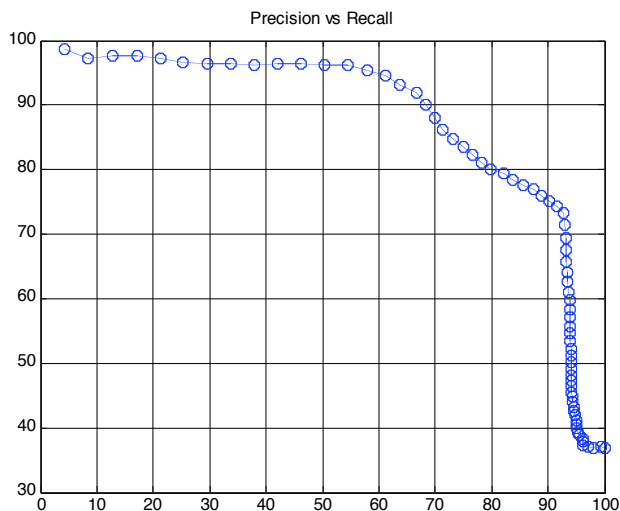Figure 3: A phylogenetic graph for the whole corpus.

Figure 4: Precision versus recall for style classification.

8. CONCLUSIONS

There are many automatic systems that compute similarity between pieces of music by measuring the distance between some musical features. One common feature is the melodic contour. Therefore, the problem of measuring musical similarity is transformed into the problem of computing distances between melodic contours. For certain type of music that approach may be appropriate and even produce good results. It is not the case for flamenco a cappella flamenco cantes, a kind of music characterized by very special features. In our previous study [3] we followed that approach and understood its drawbacks. Reducing melodic similarity to computing the distance between melodic contours leaves significant variables aside, which results in a limited similarity measure.

In the present study we took another approach. We identified a set of musical features as basis for our measure. Those musical features are related to melodic properties, duration and form and reflect in general high-level characteristics of the *cantes*. We also found some limitations. As the reader may have noticed, many *cantes* give the same feature vector and, therefore, in the phylogenetic trees they all appear on the same node. Why is that so? A moment's thought will reveal that this situation is not as surprising as it might seem at first glance. As we mentioned, the musical features account for high-level characteristics. Two *cantes* may be different at the fine detail level and yet have the same musical features. That is the hardness of dealing with flamenco *cantes*.

It is clear that in order to obtain good similarity measures musical knowledge of the particular type of music must be incorporated into the model. On the other hand, since we know this is not enough, fine detail information such as melodic contours should be incorporated, too. Thus, there should be a tradeoff between both approaches. That is the research we are presently carrying out.

The identification of the musical features of a cappella *cantes* is one of the main contributions of this paper. They have not been described before and our experiments

have proved they work quite well for inter-style classification. Our approach can be easily adapted to build a classification system based on machine learning. For the case of intra-style classification, more musical features should be identified. Our goal was to distinguish general musical features rather than specific features. This situation shows that special needs require special treatments and that inter-style and intra-style classification needs a different set of musical features.

At present all the work put forward here has been done in a manual way. First, we wanted to check that the extraction of the musical features were correct and, furthermore, gave a good measure of similarity. We are currently working on building an automatic system based on our measure. This includes the automatic extraction of the musical features from music recordings through an automatic transcription procedure.

9. REFERENCES

[1] Blas-Vega, J *Historia de las tonás*, ed. Guadalhorce, Málaga, 1967.

[2] Celma, O. Music Recommendation and Discovery in the Long Tail. PhD thesis, Universitat Pompeu Fabra, 2008.

[3] Cabrera, J.J., Díaz-Báñez, J.M., Escobar, F.J., Gómez, E., Gómez, F., Mora, J. Comparative Melodic Analysis of A Cappella Flamenco Cantes. In Conference on Interdisciplinary Musicology. Thessaloniki, Greece, 2008.

[4] Donnier, P. Flamenco: elementos para la transcripción del cante y la guitarra, *Proceedings of the IIIrd Congress of the Spanish Ethnomusicology Society*, 1997.

[5] Fernández, L. Flamenco Music Theory. Acordes Concert. 2004.

[6] Guastavino, C., Gómez, F., Toussaint, G., Marandola, F., Gómez, E. Measuring Similarity between Flamenco Rhythmic Patterns. *Journal of New Music Research*. 38(2), 129-13, 2009.

[7] Huson, D. H. SplitsTree: Analyzing and visualizing evolutionary data, *Bioinformatics*, 14:68-73, 1998.

[8] Lefranc, P. *El Cante Jondo. Del territorio a los repertorios: tonás, seguiriyas, soleares.* Publicaciones de la Univ. de Sevilla, Cultura Viva, Vol. 16, 2000.

[9] Serrá, J., Gómez, E., Herrera, P., and Serra, X. Chroma Binary Similarity and Local Alignment Applied to Cover Song Identification. *IEEE Transactions on Audio, Speech and Language Processing*, Vol. 16(6), pp. 1138-1151, 2008.

[10] Widmer, G., Dixon, S., Knees, P., Pampalk, E. Pohle, T. *From Sound to Sense via Feature Extraction and Machine Learning: Deriving High-Level Descriptors for Characterizing Music*, in Sound to Sense, Sense to Sound: A State of the Art in Sound and Music Computing, Chapter 5, 2008.